MEDICAL TREATMENT IN LIEU OF EVACUATION: TECHNIQUES FOR COMBAT CASUALTY CARE PHYSICIANS

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by

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The United States Army Medical Department delivers high quality medical care throughout the world, many times to remote and austere environments. A major tenet of this care system is the rapid evacuation of combat casualties to hospitals with surgical resuscitation. However, what happens when evacuation is unavailable? This study will explore the current literature and review trends in prehospital care in the Army. Which medical protocols should Army physicians at Role 1 and 2 facilities have available for treatment in lieu of medical evacuation?

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

MEDICAL TREATMENT IN LIEU OF EVACUATION: TECHNIQUES FOR COMBAT CASUALTY CARE PHYSICIANS, by Matthew H. Hoefer, 64 pages.

The United States Army Medical Department delivers high quality medical care throughout the world, many times to remote and austere environments. A major tenet of this care system is the rapid evacuation of combat casualties to hospitals with surgical resuscitation. However, what happens when evacuation is unavailable? This study will explore the current literature and review trends in prehospital care in the Army. Which medical protocols should Army physicians at Role 1 and 2 facilities have available for treatment in lieu of medical evacuation?

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ACRONYMS

AAFP	American Academy of Family Physicians
AAMC	Association of American Medical Colleges
ABC	Airway, Breathing, Circulation
ACLS	Advanced Cardiac Life Support
AMEDD	Army Medical Department
ATLS	Advanced Trauma Life Support
ATN	Army Training Network
BLS	Basic Life Support
BSD	Blood Support Detachment
BTLS	Basic Trauma Life Support
C4	Combat Casualty Care Course
DCR	Damage Control Resuscitation
DMMPO	Defense Medical Material Program Office
DMSB	Defense Medical Standardization Board
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities
EMT	Emergency Medical Technician
MEDEVAC	Medical Evacuation
MSTC	Medical Skills Training Center
PALS	Pediatric Advanced Life Support
TCMC	Tactical Combat Medical Care Course

CHAPTER 1

INTRODUCTION

> The bravest are surely those who have the clearest vision of what is before them, glory and danger alike, and yet notwithstanding, go out to meet it.
>
> — Thucydides

The Military Medical System

The American soldier deserves the best medical care in the world. One foundation of a soldier's ability to "go out and meet" danger is the recognition that any injury they sustain will be cared for immediately, with the best care available, with every asset available, and to the highest in standards. The Army Medical Department (AMEDD), recognizes that covenant with the soldier, and has developed a "seamless chain of care" from the point of injury back to rehabilitative care in the United States.[1] Wounded soldiers are treated first by a first responder, such as a Combat Lifesaver or an enlisted medical specialist within their unit. Next, the soldier is evacuated to a Battalion Aid Station or Brigade Support Medical Company, where they are stabilized and further treated by a Physician or Physician Assistant. Joint Publication 4-02 refers to these first levels of treatment as "First Responder Capability," and it does not include surgical interventions. If required by their injuries, the patient is transferred further along the evacuation chain to a medical unit with surgical capability, generally an Army Forward Surgical Team or Combat Support Hospital.

[1]The Army Surgeon General, "Mission," Army Medical Department, http://www.armymedicine.army.mil/about/introduction.html (accessed 4 April 2012).

In Afghanistan, during Operation Enduring Freedom, this evacuation is usually carried out via helicopter. The high elevation, mountainous topography, and increased distance between military strongholds necessitates the mobility of rotary wing air evacuation. When this system works correctly, a patient can travel from their point of injury to surgical and intensive resuscitative care within minutes, and be stabilized in a fixed facility hospital in a matter of hours. The danger lies, however, when evacuation fails and the patient is unable to make it to the specialty and surgical care a hospital provides. In these cases, injured soldiers must rely on the training, techniques, and equipment provided by first responder medical sections.

To put a perspective on the issue with failure of evacuation, it is important to review current trends in the military operational environment. One recent article reviewed a sample of 3200 patients evacuated by air during Operation Enduring Freedom (OEF) in Afghanistan, in which 50 percent of the patients were deemed to require evacuation to a hospital setting within two hours after injury in order to improve survivability. Further, over 30 percent of the 3200 patients required immediate resuscitative care at a surgical center within one hour.[2] This study highlights the importance of a robust evacuation system. Approximately 960 of the patients injured in this review would have likely died if not for successful aeromedical evacuation within a one hour time frame.

Contrast this study on life threatening injuries with data on air evacuation failures in Afghanistan during the same period. Theater evacuation times are aggressively tracked, based on policy discussed later, and provide some insight to the risk faced with a

[2]Ingo Hartenstein, "Medical Evacuation in Afghanistan: Lessons identified! Lessons learned?" *Medical Challenges in the Evacuation Chain* (Siegburg: NATO, 2008): 11.

combat evacuation system. North American Treaty Organization (NATO) military forces data shows that of 1,821 missions in the 2007 to 2008 timeframe, 142 of them failed to meet the International Security Assistance Force standard of one hour.[3] Prolonged evacuations can have many causes, including mechanical failure of the platform, failures in communication, difficulty with mission authorization, extended range and flight times, or delay in evacuation due to medical protocols. However, in all cases delay means increased time before trauma victims can reach required lifesaving treatment.

If the data from these two blocks of data were aligned, and a comparison done between life threatening injuries and the inability to evacuate them to life saving therapy, it would show 67 patients, or seven percent of the 960 patients with a surgical necessity, who were at risk of not reaching critical treatment in time to prevent death. Of course, this correlation can prove to be inaccurate. The statistics collected by NATO are concerned with the speed of evacuation, and do not follow the patient through their resuscitative care to determine the efficacy of rapid evacuation. Additionally, there are variables in evacuation that are not accounted for in the literature. For example, the failed missions could have had non-urgent patients on board, while successful missions carried urgent patients. There is also an obvious increase in motivation to complete a mission flown with a critically ill patient on board. Alternatively, failed missions due to aircraft maintenance could have been evacuated on another platform. While these two review show the possibly of failure within the military evacuation system, a complete investigation requires better parameters of measurement and more accurate data.

[3]Hartenstein, "Medical Evacuation in Afghanistan," 11.

Another way to measure success of evacuation in medical systems is through another measurement, the Died of Wounds (DOW) rate. Died of Wounds signifies the percentage of patients who survive their injuries long enough to begin treatment in a medical facility, but later die due to those same injuries.[4] Unfortunately, DOW is most accurately measured at the hospital, or Role 3, level within the military system, and accurate numbers regarding death based on treatment by first responders were not found in this study. The reasons for this inaccuracy are twofold. First, medical documentation is difficult to maintain and transfer during patient movement in an austere environment, increasing inaccuracies in patient condition and treatment reporting in transit. Second, all traumatic injuries on the modern battlefield are transferred to a hospital, no matter the probability of their death, so there is rarely a documented death at the Role 1 and 2 level of care. Work has been done by the Army Medical Department to improve patient documentation in the prehospital care setting, but to date it has not resulted in vastly improved tracking of prehospital statistics.[5]

The DOW rate during combat operations in Iraq and Afghanistan ranged from 6 to 12 percent in Role 3 facilities.[6] This statistic parallels the figure of seven percent found in the data from NATO. In all cases the military medical provider is presented with the

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[4]John B. Holcomb, Stansbury Lynn, Howard R. Champion, Charles Wade, and Ronald F. Bellamy,"Understanding Combat Casualty Care Statistics," *The Journal of Trauma Injury, Infection, and Critical Care* 60 (2009): 397.

[5]Frank Butler, "Tactical Combat Casualty Care," http://www.health.mil/dhb/downloads/Butler%20TCCC.pdf (accessed 5 May 2012).

[6]Ray Mitchell, et al., "Statistical Modeling of Combat Mortality Events by Using Subject Matter Expert Opinions and Operation Iraqi Freedom Empirical Results from the Navy–Marine Corps Combat Trauma Registry," *Journal of Defense Modeling and Simulation: Applications, Methodology, and Technology* 7 (2010): 1.

risk of a small portion of patients who may not receive timely evacuation. These patients would benefit from increased medical capability prior to their evacuation to surgical care and intensive care.

The Loss of the Generalist

As medical providers in the United States become more specialized, the amount of training they receive in general medicine decreases. Most new physicians select their specialty training during their last year of medical school and immediately focus on specialization. In fact, according to the Association of American Medical Colleges, 95 percent of medical school seniors will enter directly into a specialty training program after graduation in 2012.[7] New doctors in the United States do not participate in a historical 'apprenticeship' model of medical training, where the junior doctor spends years on a ward or in a family practice, honing their skills in medicine and surgery under a general practitioner. Instead, American doctors dive directly into their specialty training.

Unfortunately, the general practice of medicine is lost in this system. Most doctors are responsible for only a short portion of a patient's treatment, and do not become experts in the full spectrum of medical, surgical, resuscitative, and recovery care. Specialty trained physicians focus on biological systems, such as the heart, lungs, and gastrointestinal tract. Alternatively, they specialize on treating a type of disease, such as cancer, skin disease, infectious disease, or surgical intervention. According to the

[7]Association of American Medical Colleges, "Highest Match Rate for U.S. Medical School Seniors in 30 Years," https://www.aamc.org/newsroom/newsreleases/276900/120316.html (accessed April 4 2012).

American Association of Family Physicians, only 14 percent of physicians of the United States practice Family Medicine, with only 2 percent labeling themselves as generalists.[8] This means the other 86 percent of physicians have been trained in, and practice, specialized medicine for a specific disease or subset of patients. This national trend results in providers who lack the knowledge to treat a variety of life threatening conditions. The jack-of-all-trades family practitioner who can also conduct surgery and rehabilitative care is disappearing from our medical system.

Improved Medical Evacuation

A second force that pushes medical training away from its focus on generalized medicine is the ability to quickly evacuate patients to surgical and trauma centers. The Emergency Medical Service Systems Act of 1973 began a series of legislation that improved emergency care in the United States, dividing the country into 304 regions of responsibility and ensuring emergency services delivery to remote and underserved areas.[9] This system improved both the quality and speed of delivery of trauma and specialty care to Americans, removing the impetus for primary care physicians in smaller communities to train in surgical and longer-term life sustaining techniques. Only in extremely remote locations do we still find providers that are prepared to handle a variety of diseases and medical protocols on their own.

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[8]American Academy of Family Physicians, "Primary Care Physicians and Other Specialists in the U.S., by Percent," http://www.aafp.org/online/etc/medialib/aafp_org/documents/press/charts-and-graphs/primary-care-physicians-and-other-specialties.Par.0001.File.tmp/no-pricare-phys.pdf (accessed 8 April 2012).

[9]Margaret O'Leary, "A Historical Overview of EMS System Development in the U.S.: the 1960s and 1970s," Suburban Emergency Management Project, http://www.semp.us/publications/biot_reader.php?BiotID=246 (accessed 4 April 2012).

Civilian to Military Trends

These trends in civilian medical training translate directly into the skills of Army medical providers. With the exception of graduates from the Uniformed Services University of Health Sciences (USUHS), the military medical school, Army physicians receive their training from civilian institutions. In fact, according to a study completed at the U.S. Army War College, 81 percent of Army Physicians commission into the Army from a civilian source.[10] Additionally, Army medicine utilizes the civilian credentialing system within the United States to ensure the appropriate level of initial and continued certification. Army physicians are board certified by civil entities and receive their continuing medical education from civil medical societies throughout their career. This reliance on the civilian education system means that Army physicians are taught how to manage care within the civilian system, generally receiving no additional training on combat, military medicine, or long term medical sustainment in austere environments.

Dependence on Evacuation

Army physicians have also grown used to fast evacuation to a higher level of treatment. Air evacuation by helicopter, refined during the Korean War, dropped the transit time for a wounded soldier to just a few hours.[11] This ability to quickly move wounded soldiers from a Battalion Aid Station to a hospital with surgical and advanced resuscitative care has contributed to decreased Died of Wounds rates in each successive

[10]Erin Edgar, "Physician Retention in the Army Medical Department" (Masters of Strategic Studies, Strategy Research Project, U.S. Army War College, 2009), 3.

[11]Darrel Whitcomb, *Callsign Dustoff- A History of U.S. Army Aeromedical Evacuation from Conception to Hurricane Katrina* (Washington, DC: Borden, 2011), 19.

conflict, but it has also led to a dependence on medical evacuation. Much like their civilian counterparts, the ability to move badly wounded patients out of their facility has removed the impetus for first responder physicians to maintain skills in trauma treatment and resuscitation.

Adding to the robustness of the medical evacuation system, the "Golden Hour" evacuation policy was established by Secretary of Defense Robert Gates in Iraq and Afghanistan.[12] This policy increases the evacuation assets in theater and ensures that patients are moved to surgical centers within an hour of their injury. While this policy is important for appropriate care of trauma patients, the robust system of evacuation it requires leads to a high rate of successful patient transfer and high expectations for fast movement of patients away from the battlefield. What happens then, when these expectations are not met?

The Battalion Surgeon

In the context of deployable medical systems, physicians in the Army are assigned to two types of units. Either they are assigned to medical units, such as a Combat Support Hospital or Forward Surgical Team, in which the mission of the unit is to provide care to joint, coalition and other eligible patients such as contractors, on an area basis. Alternatively, they are assigned to units with non medical missions such as combat arms or combat support. Physicians in these other units serve as the Battalion or Brigade Surgeons, and are responsible for the planning and execution of all aspects of medical care to that unit, including the supervision of treatment, evacuation, preventive

[12]Donna Miles, "'Golden hour' initiative pays off in Afghanistan," *Air Force News*, http://www.af.mil/news/story.asp?id=123256862 (accessed 5 April 2012).

health, and medical logistics. These physicians assigned to non medical Army units do not generally have surgical specialty training, and their medical teams are not equipped to provide surgical, anesthesia, or intensive care. Due to the high expectations of success in our robust evacuation system, these providers are not expected to maintain the specialty skills to care for a patient over a longer term. This ability of medical professionals to provide life-sustaining treatment is most important in situations where they are the last resort.

CHAPTER 2

METHODOLOGY

All progress is experimental.

— John Jay Chapman

The Problem

This study will explore the particular scenario described in Chapter one. Are there lifesaving treatment protocols that should be available to first responder physicians when evacuation has failed or been delayed? The inability to provide evacuation to a higher level of care will require the provider to have a greater ability to assess, diagnose, and treat life threatening injuries and diseases. This is especially important when evacuation is delayed to the point where the patient must fully recover in the care of the first responder physician, such as in third world environments or long duration spaceflight.

The purpose of this study is to review the current trends in medical techniques, equipment, and training and make recommendations for military medical providers who will likely work in austere combat environments. The intent is to recommend the inclusion of new techniques, standards, training programs, medical systems, or equipment sets that will improve a first responder physician's ability to provide care when evacuation fails.

Research Question

Which medical protocols should Army physicians at Role 1 and 2 facilities have available for treatment in lieu of medical evacuation? This question leads to a number of

secondary questions to explore before recommending changes to the Army medical system.

First, we must understand the typical treatment environment for Army medical providers in a first responder care scenario. What is the duration of treatment for the most common battlefield injuries, and which injuries are being seen most commonly within the Battalion and Brigade level medical sections? Are there unique or new protocols for treating the most common injuries that are not already available to Army physicians in Role 1 or 2 units?

Second, what will be the Army wide implications to a change in medical protocol? What medical equipment is currently available in Army Medical Equipment Sets (MES), and what would need to be added to improve the capability of a Role 1 or 2 medical section? Is the cost of added equipment feasible or untenable? Additionally, what additional training and skill sustainment is necessary to ensure that physicians across the Army know how to use the new equipment in accordance with an improved protocol?

Those questions will be answered by first exploring the academic body of knowledge to see if protocols exist that are being used within the first responder care environment, and whether they may be applicable in Army units. Then, an analysis will be conducted of pertinent techniques to discuss their feasibility for inclusion in Army Medical Department techniques. While a detailed discussion of all Role 1 and 2 techniques and equipment will not be included in this study, these attributes will be reviewed as necessary to relate the body of literature to the military model of medical care.

Terms

Like any other system, in order for Army medical systems to function they must share a common language. Definitions of extent of care, types of evacuation, and concepts are central to the discussion in this study. Since the early 1980s, Army medical doctrine has changed to be inclusive of joint concepts, in order to operate better with Navy, Air Force, and Marine medical systems. More recently, and largely due to cooperation in the Middle East with international partners, Army language has aligned with North American Treaty Organization, or NATO, definitions. A number of relevant definitions are provided here in order to facilitate discussion of this study.

Medical evacuation, or MEDEVAC. The most current Army Doctrine, Army Tactics, Techniques, and Procedures (ATTP) 4-02 does not delineate between type of medical evacuation platforms, except to state that the Army conducts air and ground medical evacuation.[13] Doctrine refers to all movement of an injured soldier, form point of injury to a hospital in the United States, as medical evacuation. However, MEDEVAC is defined in Field Manual 4-02.2 as being done with "platforms especially for the medical evacuation mission with allocated medical equipment specifically designed for the purpose of enroute care and by trained medical personnel."[14] MEDEVAC is also distinguished in FM 4-02.2 from Casualty Evacuation, or CASEVAC which is the

[13]Headquarters, Department of the Army, Army Tactics, Techniques and Procedures (ATTP) 4-02, *Army Health System* (Washington, DC: Government Printing Office, October 2011).

[14]Headquarters, Department of the Army, Field Manual (FM) 4-02.2, *Medical Evacuation* (Washington, DC: Government Printing Office, May 2007).

"movement of patients on non medical vehicles."[15] Although doctrine recommends that medical personnel, such as an enlisted medic or combat lifesaver, be placed aboard CASEVAC platforms to monitor patient care, this does not redesignate the platform as MEDEVAC.

Prehospital care. Prehospital care is all medical care given prior to admittance into a hospital facility or emergency room. This term is used for Emergency Medical Technician and ambulance care in American civilian medical systems. Prehospital care, also known as First Responder Care, encompasses the earliest techniques of Forward Resuscitative Care in the military medical system and is provided by buddy aid, Combat Lifesavers, and Enlisted Medical Technicians, or combat medics, and possibly physicians. The military and civilian definitions do not directly correlate because a military patient will receive both prehospital care and emergent hospital, or emergency room, care while in Role 1 or 2 facilities.

Roles. The U.S. military medical system uses roles of care to divide the treatment capabilities of medical treatment facilities. Historical systems and the systems of other nations also use the terms level and echelon, as well as sub roles such as Role 2 Enhanced or Role 2 Plus. The term "level" is a traditionally American term also used in the civilian sector. The term "role" is a recently adopted delineation established by North American Treaty Organization forces to maintain a common language among signatory nations, and is the current Army policy as stated in the manual for Army Tactics, Techniques and

[15]Headquarters, Department of the Army, FM 4-02.2.

Procedures (ATTP) 4-02.[16] Differences do occur between the definitions of role and level, but the term role will be used for the purposes of this study and differences in the terms are delineated below.

Roles 1 and 2. The first two roles of care exist in a Battalion or Brigade. In a linear geographic model, these medical facilities are established furthest forward on the battlefield, in direct support of their parent unit, and designed to provide short-term acute care services for approximately 300 to 500 soldiers in a Battalion or 2000 to 4000 soldiers in a Brigade. The staff of both the Role 1 and Role 2 medical sections consist of a physician and a physician assistant as well as 6 to 20 enlisted medical specialists. This level of care is responsible for treating day-to-day illness as well as combat injuries. Trauma care at this level is generally limited to fluid resuscitation, stabilization of wounds and fractures, and control of blood loss through compression and bandaging. Role 1 and 2 medical sections do not provide surgical care, long term holding, intensive, or nursing services. However, the addition of a patient hold section, xray diagnostics, and minimal laboratory equipment allow Role 2 facilities to maintain blood, provide enhanced diagnostics, and hold patients for a short term up to about 72 hours. Additionally, the attachment of a Forward Surgical Team or FST to a Role 2 unit is commonly done based on operational requirements. This hybrid unit is colloquially referred to as a Role 2 Plus in the United States Army, and has correlates in NATO doctrine as a Role 2 Enhanced.[17] While commonly used in U.S. Army operations, a Role

[16]Chairman, Joint Chiefs of Staff, Joint Publication (JP) 4-02, *Health Service Support* (Washington, DC: Government Printing Office, October 2006), I-2.

[17]Ibid.

2 Plus structure is not defined in ATTP 4-02 and does not exist as an established medical unit. Collectively, care at and below the level of Role 2 is referred to as First Responder Capability in joint doctrine and discussed as prehospital care in civilian systems.[18]

Roles 3 and 4. The addition of surgical capabilities set Role 3 units apart from First Responder Care capabilities. Normally a Corps asset, such as a Combat Support Hospital, a Role 3 unit operates similarly to civilian fixed facilities. Role 3 facilities serve as theater collection points for casualties and provide intensive care and patient holding services as well extensive lab, therapy, and ancillary services. Role 4 units are fixed facilities, operating in a safe environment, either outside or inside the Contiguous United States. These units provide all of these services attributed to major civilian medical centers, specifically including long term surgical and recovery care as well as rehabilitative services.

The Golden Hour. Dr. R. A. Cowley, a trauma surgeon, first coined this term in 1969. The golden hour is an evacuation concept based on increased survivability of trauma patients who receive surgical intervention within the first 60 minutes after injury.[19] Research supporting the golden hour premise was done in U.S. trauma centers in the 1960s and 1970s and is also loosely based on the improved survivability of traumatic injuries between the Korean and Vietnam Wars. As stated previously, average evacuation times in these conflicts dropped from around five to one hour, primarily due to increased use of helicopter medical evacuation. More recently, the 'platinum 10' refers to increased

[18]Chairman, Joint Chiefs of Staff, JP 4-02, I-2.

[19]E. B. Lerner and R. M. Moscati, "The Golden Hour: Scientific Fact or Medical 'Urban Legend?'" *Academic Emergency Medicine* 8 (2001): 759.

survivability in patients who receive proper prehospital care, including the stoppage of bleeding and start of fluid resuscitation, within the first 10 minutes of injury.[20] However, more recent studies have failed to show an absolute relationship between survivability and evacuations faster than sixty minutes.[21] This new data is leading trauma specialists to explore more specific requirements for the timing of evacuation in the case of traumatic injuries. Within this study, we will assume the validity of the golden hour concept, with the premise that rapid transfer to a higher level of medical care is almost always in the best interest of the patient.

Assumptions

For the purpose of this study, the targeted medical providers are Army physicians who have completed at least one year of rotational internship or clerkship training. These physicians are traditionally labeled as General Medical Officers (GMO), and may or may not have had additional residency training. Specifically, these physicians have not been trained in surgical or emergency medicine techniques, and do not participate in those types of protocols on their normal practice of medicine.

The targeted medical units for this study will be Role 1 and 2 medical sections, serving United States Army Battalion and Brigade sized units, referred to in Joint

[20]Kara Rogers, "Battlefield Medicine: The Golden Hour and the Platinum Ten," Encyclopedia Britannica Website, http://www.britannica.com/blogs/2011/06/battlefield-medicine-golden-hour-platinum-ten/ (accessed 8 April 2012).

[21]Craig D. Newgard et al., "Emergency Medical Services Intervals and Survival in Trauma: Assessment of the 'Golden Hour' in a North American Prospective Cohort," *Annals of Emergency Medicine* 55 (2010): 235.

Doctrine as having First Responder Capability.[22] Although Physician Assistants also serve as medical providers in these types of units, their civilian training and certification paths are different from that of a physician and their role is not discussed here in order to limit the scope of this study. Because the basic medical equipment in a Role 1 and 2 section are identical, their capabilities will be discussed synonymously. Exceptions to this rule will be discussed as necessary, especially when noting the additional ancillary services previously attributed to Role 2 medical sections.

Treatment protocols reviewed in this study are drawn from the body of literature, and are not limited to current U.S. Army medical equipment sets and practices. However, because of its focus on deployable military medicine, techniques discussed will maintain limitations in electrical power and consumption of disposable medical supplies. That is, training and protocols reviewed may require a minor change in military medical equipment, but should not require a significantly larger logistical throughput or change to the unit power plant.

Additionally, the study assumes any increased ability to treat patients at Role 1 facilities will be favorable to patient outcomes. The purpose is not to provide capabilities to a first responder medical section which cause them to delay evacuation when it is available. This would ignore a basic tenet of combat medicine, which is to clear injuries from the battlefield and prepare for continued operations as quickly and safely as possible. Any research, which slows evacuation, overburdens Role 1 and 2 providers, or shows degradation in patient survivability, will not be included.

[22]Chairman, Joint Chiefs of Staff, JP 4-02, I-2.

Finally, training systems and techniques which are reviewed and recommended within this study will meet the scope of practice for prehospital care in the United States. Techniques and equipment which are not authorized or approved by legislative and professional medical bodies will be excluded from the study.

Limitations

The author is an Army Physician and has served for seven years as a provider in Role 1, Role 2, and fixed facility medical units. Additionally, he has deployed to austere and combat environments three times, providing medical care in the first responder role. He is specialty trained as an Aerospace Medicine physician, a primary care and occupational health specialty. Therefore, he has limited experience in surgical resuscitation or intensive care. Determinations made in this study are partially biased by the authors professional training and practical experience, as well as his comfort with specific protocols and skill sets.

Scope and Delineations

This study is based on a qualitative review of literature on the topic presented and will not explore statistical links between findings. It will examine the expected results for differing medical protocols and expectations for changes in patient survival. The study will also analyze initial costs of implementing new medical protocols, but will not review second order implications for any change in Army policy or Army Medical Department protocols.

Significance of Study

The significance of this study will be seen in its effect on future treatment protocols, equipment, and training programs within military medicine. Most of the current body of knowledge regarding traumatic injury and combat medicine is based on studies completed at surgical and hospital venues, which focus on patient results after they reach the emergency room or surgical suite. This data is biased due to the intervention of a surgical or emergency medicine specialist, with the training, experience, and equipment to provide high level resuscitative care. However, little focus is made in the professional literature on prehospital techniques and their results. The research presented in this study reviews literature from both hospital and prehospital care and attempts to determine which findings result in the greatest success in forward resuscitative and first responder settings.

Success in these venues, which are nearer injury locations and provide earlier treatment, is paramount to the military medical provider. Earlier treatment of combat injuries on the battlefield should increase the survivability of patients and improve the delivery of combat healthcare. Additionally, a continued focus on the delivery of prehospital care in the military setting is important for the Army Medical Department to maintain its lessons learned during the past ten years of war. As in most aspects of combat, the price of forgetting the lessons of war is paid by the loss of lives. A continued exploration of techniques, equipment, and training will find significance when the next generation of combat medical providers is prepared to treat and save American soldiers.

Technique

This study is a literature review of United States Army doctrine and civilian professional articles related to the delivery of medical care in pre-surgical and non intensive care environments. The study was conducted using the resources of the Combined Arms Research Library and the Army Medical Department Virtual Library. Articles reviewed were in English, came from peer reviewed medical literature, and were published within the last fifteen years. Additionally, civilian and military web sources were utilized to develop historical background and research the authoritative source of each topic within the study. Using the academic libraries noted above, topics during this study include; medicine in austere environments, army medical doctrine, space medicine, mountain medicine, wilderness medicine, third world medicine, expedition medicine, rural medicine, medical evacuation, combat casualty care, trauma casualty care, combat prehospital care, emergency medical systems, and military prehospital care.

CHAPTER 3

LITERATURE REVIEW

> When faced with an Austere Environment, the philosophical approach to the patient must change.
>
> — James P. McClay

Introduction

As medical technology advances, new techniques and equipment are making their way into increasingly remote environments. In his 2011 book, *Ballistic Trauma, a Practical Guide*, Peter Mahoney states that, "Sophisticated critical care can be provided worldwide, even where advanced infrastructure with sophisticated technology is unavailable."[23] This type of medical care is expanding as we expand the reaches of humankind, both on the globe and off. Resources for austere medicine occur in many areas of practice, described by Hogan in 2007, in *Disaster Medicine,* as "performed in military medicine, wilderness medicine, expedition medicine, and rural medicine."[24] Through the last ten years of warfare in the Central Command region, most new research and literature has been produced in the area of military medicine. However, there is an increasing amount of academic study being conducted on space medicine, specifically in the area of deep space exploration support.[25] *The Fundamentals of Aerospace Medicine,* published in 2008 by a group of aerospace and operational physicians, focuses on the

[23]Peter F. Mahoney, *Ballistic Trauma: A Practical Guide* (London: Springer 2011), 295.

[24]David E. Hogan et al., *Disaster Medicine* (Philadelphia: Lippencott, 2007).

[25]Jeffrey R. Davis et al., *Fundamentals of Aerospace Medicine* (Philadelphia: Lippencott, 2008).

physiological effects of spaceflight. Although these literary resources have value in their fields, they support specialized medical practices. Only in consolidation will they serve as useful to a general practitioner. This study explores the different types of medical debilitation and the protocols being used to care for patients in extreme environments.

One tenet of medicine in austere or extreme environments is the establishment of an "acceptable minimal level of care."[26] Discussed in *Disaster Medicine* by James McClay, it is the idea that the physician needs to establish treatment objectives with the realization that the appropriate level of care will not be attained. These minimal objectives include; maintenance of vital signs, prevention of further injury, a utilitarian delivery of therapy, pain control, reassurance, and reassessment of evacuation options.[27]

Diagnostic Protocols

In 2008, a military medical team at the U. S. Army Institute of Surgical Research conducted a pilot study on the use of ultrasound as a diagnostic and confirmatory test for fracture.[28] Currently, the standard of medicine requires an xray to confirm a fracture before it is treated. An additional xray is required after management to ensure that the bone has been returned back into its proper place, or reduced. The xray confirms alignment after a splint, cast, or other immobilization protocol has been applied. The film also serves as an aid in confirming that no significant damage has been done to

[26]James P. McClay et al., "Managing Disasters in Extreme Environments," in *Disaster Medicine* (Philadelphia: Lippencott, 2007), 174-175.

[27]Ibid.

[28]J. G. McManus, "Use of ultrasound to assess acute fracture reduction in emergency care settings," *American Journal of Disaster Medicine* 3 (2008): 241-7.

surrounding tissues, vessels, or nerves. Their technique, outlined in the *American Journal of Disaster Medicine,* is important for the first responder physician because Role 1 medical sections do not have xray capability. The diagnosis of fracture is made without a confirmatory xray and unstable breaks must be evacuated to a facility with radiology equipment. The treatment of uncomplicated fractures is fairly simple, and within the equipment and skill set of a Role 1 facility, so an alternative to the xray would serve well at that level. The test group, although small, demonstrated the feasibility of an ultrasound unit in the management of fractures in emergency departments and medical sections.

Ultrasound is used to differentiate between the densities of structures within the body, and is especially helpful in denoting the borders of tissues, organs, and other soft anatomical structures. Hence, it has many uses as a diagnostic tool. Whitfield demonstrated its utility in the treatment of a retinal detachment. Resulting from a gunshot wound to the face, the patient had a closed globe traumatic retinal detachment due to pressure forces from the bullet. Stabilization of a probable retinal detachment would normally be cause for evacuation to a fixed medical facility and a bulky suite of diagnostic equipment, as well as supervision by an ophthalmological specialist. However, in this 2011 article in the *Journal of Emergency Medicine*, Whitfield was able to demonstrate a successful protocol for the diagnosis and treatment of this injury with portable ultrasound techniques.[29]

An important measure of viability in a trauma patient is oxygenation. Although oxygen saturation of the blood can be acquired via oximetry on the skin surface, the most

[29]D. A. Whitfield and S. J. Portouw, "Retinal Detachment Due to Facial Gunshot Wound: The Utility of Ultrasonography in a Medically Austere Environment," *J Emerg Med* (2011): 16.

accurate measurement is an arterial blood gas. This test provides the oxygen and carbon dioxide saturations, pH, and hemoglobin concentration of arterial blood; important indicators in the management of patients in pulmonary distress due to traumatic injury or pulmonary infections. The typical technique for drawing a sample of arterial blood is to puncture and draw from the radial or femoral arteries, the wrist and groin respectively. Unfortunately, this procedure requires a clean environment and skillful technique in order to prevent damage to vital vessels. Additionally, the incision of arterial vessels in the field environment greatly increases the risk of infection. In a 2006 article in *Aviation, Space, and Environmental Medicine* entitled "A device for sampling arterialized earlobe blood in austere environments," Russomano et al developed a piece of technology that gains the same test fidelity as a manual arterial blood draw, with a lesser degree of skill necessary, and without introducing major vessels to an extreme or unclean environment.[30] The new equipment, the Earlobe Arterial Blood, or EAB, collector is a semi automatic device, which aligns on the earlobe on places a 2-4 mm incision with a sterile micro scalpel. Then, the device draws an anaerobic sample of arterial blood into a set of capillary tubes for testing. Laboratory testing of samples in Russomano's study were equivalent to a standard arterial blood draw, but using the earlobe as a draw site significantly limits the transmission of bacteria and allows for a less skilled operator.

Resuscitative Protocols

A primary concern when treating a trauma patient is the prevention of shock, from hypovolemia or other causes. Shock is simply defined as the loss of blood flow through

[30]T. Russomano et al., "A device for sampling arterialized earlobe blood in austere environments," *Aviat Space Environ Med* 77 (2006): 453-455.

the body, causing damage to vital organs.[31] Resuscitative care includes actions taken to restore blood volume, maintain appropriate body temperature, or reduce systemic infection. Resuscitative care is generally the purview of the intensive care physician, operating in a fixed facility with a robust staff and banks of monitors. However, many of the intensivist's lessons can be passed down to physicians practicing forward resuscitative care.

In a June 2011 overview of resuscitation techniques, Colonel Michael Murray outlined four pillars of resuscitative care on the battlefield:

> 1. For acutely injured troops, the administration of crystalloid fluid should be minimized until bleeding is controlled.
> 2. Normothermia (>36.5°C) should be maintained as much as possible throughout transport to the closest treatment facility.
> 3. Patients having any signs that identify them as being at increased risk of developing a coagulopathy should receive a ratio of one unit of fresh frozen plasma for every unit of blood administered.
> 4. Coagulopathic patients are candidates to receive Recombinant Factor VIIa, and if bleeding is excessive, may be administered warm fresh whole blood.[32]

In his article, titled "Review: The Influence of Armed Conflict on the Development of Critical Care Medicine" Dr. Murray reviewed these tenets, which provide a more focused protocol than the practice of delivering intravenous therapy, such as lactated ringers or saline solution, to every patient. The concept of permissive hypotension until bleeding

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[31]U.S. National Library of Medicine and National Institutes of Health, "Shock" Medline, http://www.nlm.nih.gov/medlineplus/ency/article/000039.htm (accessed 11 April 2012).

[32]Michael J. Murray, "Review: The Influence of Armed Conflict on the Development of Critical Care Medicine," *Military Medicine* (2011): 676.

control is established is key in the Army's training shift towards blood loss control techniques like increased use of tourniquets and splinting in the field.[33]

Administration of Fluids

The delivery of volemic venous resuscitative care can be especially difficult in a combat environment. Blood loss due to delays in evacuation and violent injuries cause vessels to deflate and become more difficult to infuse with an intravenous line. Additionally, traumatic amputations from combat and blast injuries remove the typical intravenous injection sites. Intraosseous intravenous devices provide an opportunity to place a resuscitative line directly into the inner bone space, typically of the sternum or patella. In his groups review titled in the *International Journal of Critical Illness & Injury Science* titled "Advances in prehospital trauma care," Dr. Williamson noted comparison studies that have shown similar perfusion rates between intraosseous and intravenous sites, and similar time spans to gain a viable injection port.[34] In addition, intraosseous injections require less skill to complete, in fact most types of kits can be completed by following the in package instructions. However, the introduction of a needle into the inner bone is much more traumatic for the patient, and has a greater risk of infection. In addition, intraosseous ports are not able to receive blood products as resuscitative care. These drawbacks relegate intraosseous access techniques to a secondary or emergency option in most medical facilities.

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[33]Robert Little, "U.S.Military Widening use of Tourniquets," *Baltimore Sun*, 2 May 2002.

[34]K. Williamson, R. Ramesh, and A. Grabinsky, "Advances in Prehospital Trauma Care," *International Journal Of Critical Illness & Injury Science* 1 (2011): 46.

Once access has been achieved, the physician can begin fluid resuscitation. In a 2011 article in the United States Army Medical Department Journal, Dr. Michael Dubick reviewed the concept of "Damage Control Resuscitation."[35] Closely following the first and third of Colonel Murray's tenets discussed above, Damage Control Resuscitation follows two goals in the treatment of severely wounded soldiers. The first goal is maintenance of a permissive hypotension, a systolic blood pressure of about 80mm Hg, to prevent increased bleeding due to high vascular pressure and perfusion. The second goal is a return to the proper level of blood volume using a mixture of plasma and red blood cells in a 1:1 ratio.[36] This mixture is a shift from most of the resuscitative research completed in the 1900s and 2000s, which focused on non biologic replacement agents like lactated ringer's solution or normal saline. The use of biologic products like red blood cells and plasma are important in the prevention of coagulopathy, or an inability of a patient to produce clots and stop systemic bleeding. While plasma and blood are not currently available at Role 1 and 2 facilities, research is being conducted to develop a safe freeze dried plasma solution for remote locations. Additionally, blood products are stored and managed at Role 3 hospitals and Blood Support Detachments (BSD) in theater, and are regularly shifted to lower echelons for short periods as operational needs warrant.

[35]Michael A. Dubick, "Current Concepts in Fluid Resuscitation for Prehospital Care of Combat Casualties," *The United States Army Medical Department Journal* (April-June 2011): 18-19.

[36]Ibid.

Burn Protocols

Understanding the treatment of burn injuries is paramount to a physician in a combat environment. Burns make up 5-7 percent of combat injuries.[37] Although damage to skin, muscle, and possibly internal organs can be dramatic, the primary concern in a burn injury is the management of burn shock through fluid resuscitation. Thermal damage draws moisture away from the body, and open wounds allow moist tissues to face desiccation. A group led by Major Kevin Chung discussed this issue in the study, "Advances in Prehospital Burn Resuscitation for the Combat Injured."[38] Typically, burn trauma resuscitation is based on twenty four hour period of fluid infusion. Once an estimate of the required amount of replacement fluid is calculated, half of that is given in the first eight hours, with the remainder over the next sixteen hours. A simple protocol, but the method of calculating the total is complicated and varies among specialty organizations. Chung developed a simple "Rule of 10" that gives providers a fast way to determine a fluid total. Using the estimated burn percentage of the patient's Total Body Surface Area, or TBSA, multiply by 10. Then increase the fluid rate by 100cc per hour for every 10Kg of patient body weight over 80Kg.[39] This fluid protocol, along with the Army Institute of Surgical Research burn resuscitation clinical practice guidelines, provide the Role 1 or 2 physician with an appropriate management of burn patients until evacuation can be arranged.

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[37]Clifford Cloonan, "Profiles in Combat Casualties," *Operational Medicine*, http://www.operational medicine.org (accessed 12 April 2012).

[38]Kevin K. Chung, "Advances in Prehospital Burn Resuscitation for the Combat Injured," *The United States Army Medical Department Journal* (April-June 2011): 55-56.

[39]Ibid.

Trauma Protocols

The standard approach to trauma protocols, and the first thing taught in any medical rescue course, is the Airway, Breathing, and Circulation (ABC). This mantra indicates the priority for screening the biological systems necessary to live. The ability to oxygenate blood and circulate it to vital organs is central to life; therefore ensuring that the patient has a patent airway in order to pass air to the lungs is the first step in emergency care. The technique of direct laryngoscopy is the gold standard used in hospitals, inserting an endotracheal tube into the airway using a bladed laryngoscope to open the airway, clear any anatomical structures such as the tongue and soft palate, and visualize the opening of the vocal cords. Direct laryngoscopy requires continuous training to remain proficient, and most emergent laryngoscopy in a civilian hospital is done by specialists, either emergency medicine or anesthesiology physicians. Laryngoscopy in the field, especially with the introduction of low light conditions, facial or neck trauma, airway burns and trauma, and blood or debris obfuscation, becomes an increasingly difficult task for a physician who does not have a high level of repetitive proficiency in the task. In a 2011 issue of *International Journal of Critical Illness & Injury Science,* Dr. Williamson et al. reviewed the advent of video assisted laryngoscopes into hospital and prehospital settings. Video assisted laryngoscopes secure the airway with the same result, placement of an endotracheal tube, but do so with the assistance of fiber optic camera at the tip of the instrument. This addition allows for better visualization of the vocal cords, and does not require the technician to rotate the patient's neck to see down the curved airway. These changes mean a less practiced provider can get the same result with less trauma to the patient. They can also complete the technique with better visibility through

blood and debris, and in low light conditions.[40] This ability to intubate in the field removes some of the necessity for fast evacuation, as prehospital providers are better able to stabilize a patient before they are transported.

The third portion of the ABC's, circulation, refers to the body's ability to cycle oxygenated blood throughout the body and maintain perfusion of major organs, especially the heart and brain. While initially this screen intends to determine if the heart is beating, and compensate for any issues, circulation also speaks to the appropriate level of blood volume in the body and the prevention of shock. In "Advances in Prehospital Care," Williamson also reviews therapies for controlling blood loss in traumatic injuries. Tourniquets, which have been a tool of combat surgeons since the Roman Empire, fell out of use in the American Army due to concerns about the viability of limbs. Tourniquets are widely used during surgeries; where the duration of place can be strictly controlled, but the use of tourniquets in the field was restricted because surgeons were worried about tissues destruction if blood was kept form the limbs for too long. Additionally, toxins built up in stagnant limbs could possibly race into the general bloodstream and have an oxidizing effect on the heart and vasculature. Much of this research has been refuted in the past ten years, and tourniquets are credited with saving lives on the battlefield.[41]

Another tool finding use in the control of blood loss is coagulative agents. Research into platelet function and the clotting cascade has provided first responders with

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[40]K. Williamson, R. Ramesh, and A. Grabinsky, "Advances in Prehospital Trauma Care," *International Journal Of Critical Illness & Injury Science* 1 (2011): 45.

[41]Ibid.

the ability to place agents into wounds to stop bleeding. Impregnated either into a bandage, or as a powder that is poured into an open wound, these agents provide a chemical rather than a physical barrier to blood loss. However, while tourniquets have been reintroduced in the medical kits of Role 1 and 2 medical units, blood clotting products have had a turbulent time finding their niche.[42] Some of these hemostatic agents are also heat producing, with an additional benefit of fusing torn tissue within the wound. Unfortunately, the resultant heat can also cause burns and damage to surrounding nerves or vessels, and the fused tissue makes it harder for surgeons to eventually attempt a repair. These drawbacks have led the Army to continue the search for a coagulative agent that could have widespread use among prehospital care providers.

Bijan Kheirabadi completed a thorough review of coagulative, or hemostatic, agents in the April thru June issue of the United States Army Medical Department Journal. His work showed that of 982 recent combat deaths, 20 percent may have been prevented with faster hemostasis, or bleeding control. Of those deaths, two thirds were non compressible wounds.[43] That is, the bleeding was in a location on the body where it would not have been controlled by direct pressure on the wound or application of a tourniquet. Currently, the only therapy for non compressible wounds is surgery. However, hemostatics provide an adjunct for the prehospital physician in treating blood loss before surgical intervention. Products such as WoundStat, HemCon, and QuickClot showed efficacy controlling venous or moderate arterial bleeding, and although not

[42]Williamson, "Advances in Prehospital Trauma Care," 47.

[43]Bijan Kheirabadi, "Evaluation of Topical Hemostatic Agents for Combat Wound Treatment," *The United States Army Medical Department Journal* (April-June 2011): 25-34.

included in the Army's standardized Medical Equipment Sets, or MES, saw use as an additional item in first responder units. However, the inability to definitively control high pressure arterial bleeding, as well as the thermodynamic side effects mentioned previously, have limited their dispersion in the Army.

CHAPTER 4

ANALYSIS AND DISCUSSION

Overview

In an analysis of prehospital protocols, it is important to recognize the environment of the treatment. In military medicine, Role 1 and 2 medical units are doctrinally established in tents, with cots or gurneys as beds, with tent flaps as doors and sometimes without the benefit of a floor to cover the ground. Additionally, these units operate in a tactical environment. That is, they need to compensate for the need for sound and light discipline, and have restrictions on resources such as electrical power and medical supplies.[44] Understanding this environment, the key to first responder capability is not to provide better treatment than a military hospital. On the contrary, the best course of action for a trauma patient is rapid evacuation to that higher level of care. Barring evacuation however, the key is a provision of a standard of care that is similar to a hospital setting, but provided sooner and in a poor prehospital environment.

This analysis of medical protocols in lieu of evacuation will answer the research questions posed by reviewing two general areas. First, did the literature review uncover medical protocols, equipment, or techniques that would be beneficial in treating common injuries seen in Role 1 and 2 medical units? Second, what is the effect of implementation of these protocols on the Army? That is, what changes will have to be made to acquisition, sustainment and training entities within the Army to execute these changes

[44]Headquarters, Department of the Army. Field Manual (FM) 8-10-1, *The Medical Company: Tactics Techniques and Procedures* (Washington, DC: Government Printing Office, December 1994), 3-9.

and make them successful. This second question will be answered with a review of specific portions of Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities (DOTMLPF), and attempt to bring to light any significant hurdles to implementation.

DOTMLPF assists Army planners in building an assessment for changes in the way the Army operates, such as new policy, testing standards, or equipment systems.[45] Since the scope of this study is restricted to the review of medical protocols and equipment, it deals will only a portion of the DOTMLPF tool. Therefore, this analysis will review only the Training and Material portions of DOTMLPF.

This study reviewed articles from 38 publications, listed in the bibliography, the majority of which were peer reviewed medical journals or books. Based on the literature review, there are a number of medical protocols, procedural techniques, or systems of equipment that would be beneficial in the early care of Army wounded. These protocols provide important solutions to the problem of providing lifesaving care when evacuation from Role 1 or 2 medical units fails.

Protocol 1: Ultrasonography

The use of ultrasound provides diagnostic capability comparable to a hospital radiologic suite when assessing gross tissue changes and trauma. This capability is invaluable when handling musculoskeletal injuries, and will reduce the burden of evacuation of these soldiers to a higher level of care. Additionally, the literature shows that continued and comparative data can be collected on smaller anatomical structures,

[45]Headquarters, Department of the Army, Field Manual (FM) 1, *The Army* (Washington, DC: Government Printing Office, June 2005).

such as the optic nerve.[46] This capability does not currently exist in the equipment sets of Army Role 1 and 2 medical units, but has been tested at this level in the combat environment with equipment purchased prior to deployment.

While expert use of ultrasound is a difficult task, and requires years of experience, training to a moderate level with the fidelity of a portable ultrasound is relatively simple and can be achieved at the unit level. Additionally, portable ultrasound devices are commonly being used in hospital emergency rooms, and physicians conducting cross training at the installation level will likely gain experience in ultrasound techniques. The cost of a portable ultrasound, however, may make its addition to the MES untenable. At $8,000 to $10,000, the cost may be prohibitive for a piece of equipment that does not provide emergent lifesaving therapy.[47] However, ultrasound will improve patient care and decrease evacuation requirements, and should be included in Role 1 and 2 facilities. If fiscal priorities limit full deployment of this capability, a partial fielding should at least be included for especially remote prehospital facilities.

[46]D. A. Whitfield and S. J. Portouw, "Retinal Detachment Due to Facial Gunshot Wound: The Utility of Ultrasonography in a Medically Austere Environment," *J Emerg Med* (2011).

[47]General Electric Healthcare, "VScan Ultrasound Imager," http://vscanultra sound.gehealthcare.com/?utm_so rce=Google&utm_medium=ppc (accessed 12 April 2012).

Protocol 2: Blood products

The ability to replace blood loss with biological volume is paramount to the survival of trauma victims.[48] However, Role 1 and 2 medical units do not currently have blood products in their inventory. The management of whole blood and fresh frozen plasma is a complicated process, with restrictions in storage temperature and timeline. Blood can be frozen to increase its longevity, but requires stable handling and must be used quickly when prepared.

The decentralization of Role 1 and 2 units on the battlefield also limits the use of blood products. A valuable and limited resource, blood products would be wasted in a facility which did not use them in a timely manner patients. Additionally, trauma patients sometimes require vast quantities of blood during a surgical resuscitation. The dispersion of blood products across the battlefield would delay consolidation of therapy when it was needed most.

The increased use of Hextend, along with advances in freeze dried plasma, in prehospital environments has improved the resuscitation capability of these physicians, replacing the harmful effects of overdosing a trauma patient on fluid resuscitation.[49] Used properly, these modalities have a place in the first responder environment. However, the inclusion of fresh blood products in forward, non surgical, environments will waste resources. The ability to manage these products is beyond the current training of Role 1

[48]Steven G. Venticinque, and Kurt W. Grathwohl, MD, "Critical care in the austere environment: Providing exceptional care in unusual places," *Critical Care* 36, no. 7 (July 2008): S284-S292.

[49]Kheirabadi, "Evaluation of Topical Hemostatic Agents for Combat Wound Treatment," 25-34.

and 2 personnel, and the cost of modifying current sets to handle blood products will likely be prohibitive.

Protocol 3: Video Laryngoscopy

The protection of a patent airway is vital to life. The insertion of an endotracheal tube via laryngoscopy is a time sensitive procedure normally completed in the worst of situations. Traumatic injury increases the likelihood of a blocked airway due to tissues, fluids, bone, or other debris, making it increasingly difficult to see the vocal cords and properly place the endotracheal tube. The literature shows an increased probability of having a successful airway placement with the video laryngoscope, especially in the hands of an inexperienced provider.[50] For Role 1 and 2 physicians, who generally do not have the benefit of numerous intubations in their daily practice, this ability is especially important. Additionally, the video laryngoscope allows additional providers, such as enlisted medical specialists to complete the task of intubation with increased proficiency. This ability is vital to a patients survival in the field or in situation with multiple trauma patients, when a physician or physician assistant is not readily available. Finally, the video laryngoscope decreases the amount of trauma to the physiologic, or natural, airway during the procedure of intubation. Preventing injury to the natural airway prevents increased swelling and laryngeal fracture, decreases blood and fluid losses, and allows for a faster return from intubation.[51]

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[50]R. T. Gerhardt, "Prehospital and emergency care research at the US Army Institute of Surgical Research: Enabling the next great leap in combat casualty survival," *US Army Medical Department Journal* (April-June 2011): 82-6.

[51]Gerhardt, "Prehospital and emergency care research at the US Army Institute of Surgical Research," 82-6.

The provision of video laryngoscopes is a short hurdle for the Army. At around $1,000 for a reusable laryngoscope, and around $50 for its disposable accessories, the cost for inclusion in Medical Equipment Sets is minimal.[52] Additionally, because it is a commercial product, the laryngoscopes fit under a product warranty and would be a negligible burden for medical maintenance technicians. The training portion of implementation is also relatively easy. Physicians receive training in laryngoscopy during their internship and residency, and most have at least a minimal proficiency.[53] Providing the video laryngoscope to Role 1 and 2 medical units triggers a training opportunity for enlisted medics, which give them an additional tool and provides continuing education for physicians. Additionally, the continued training of video laryngoscopy could be added as a task for Installation Medical Skills Training Centers (MSTC) at little to no additional cost.

How Does the AMEDD Operate?

Standardization of Policy

Medical Material

The Department of Defense has a method in which to make changes to the way military physicians operate. A Department of Defense Directive published in June of 1984, established the Defense Medical Standardization Board. The purpose of this board was to standardize the acquisition and fielding of deployable medical systems and

[52]Minh Le Cong, "Brief Review of the King Vision Video Laryngoscope," EMCrit Blog, http://emcrit.org/review/king-vision-laryngoscope/ (accessed 3 May 2012).

[53]Gerhardt, "Prehospital and emergency care research at the US Army Institute of Surgical Research," 82-6.

medical material sets across the military services in order to improve logistics efficiency and decrease costs. Now organized as the Defense Medical Materiel Program Office (DMMPO), this joint agency also has the mission of managing the lifecycle of medical material and is responsible for the testing and evaluation of medical equipment.[54]

This multi-service office meets under the direction of the Assistant Secretary of Defense, Health Affairs. The organization is logistics focused in nature, but has the directive to develop deployable medical systems and provide clinical advice relating to those sets.[55] This board must review clinical procedures expected in deployed environments, and ensure that sets are supplied to support the treatment. However, the DMMPO does not have any responsibility toward the training of medical providers.

Medical Treatment

The standardization of medical treatment across the joint service does not follow the same model as DMMPO does for material. Although decisions made at DMMPO and dozens of other organizations guide medical treatment protocols in deployed units, the responsibility for the standardization of treatment falls on the service. The Army Medical Command (MEDCOM) has direct reporting responsibility to the Department of the Army to both develop medical policy for the Army, and also execute it with MEDCOM's medical units and hospitals.[56] The Army Surgeon General's instrument to execute the

[54]Defense Medical Material Program Office, "Mission," https://www.dmsb.mil/home.asp (accessed 17 April 2012).

[55]Department of Defense Medical Standardization Board, "Department of Defense Directive," 21 June 1984, http://handle.dtic.mil/100.2/ADA272427 (accessed 4 April 2012).

[56]The Army Surgeon General, "Mission."

mission of oversight for medical protocols is the Army Medical Department Center and School (AMEDDC&S) at Fort Sam Houston. The AMEDDC&S is responsible for all Army training related to the delivery of healthcare. Within this institution, two unique organizations have the responsibility for developing doctrine and standards of care for medical units. The Center for Pre Deployment Medicine (CPDM) develops training based on lessons learned to provide a "just in time" product to deploying providers.[57] The Department of Medical Science has the responsibility of integrating new techniques and procedures into the policy of the AMEDD. Together, these two departments build the tactical capabilities for Army medical units.

Medical Training

As discussed earlier, most of an Army physician's training occurs under a civilian model. There is very little focus on military or combat medicine within that model. Additionally, since no physicians operate in the prehospital setting in the United States, few programs exist which concentrate on the first responder care discussed in this study.

Medical Skills Training Center

For the majority of Army physicians, the only first responder training they receive is a certification in civilian programs. These events include regular updates in Basic Life Support (BLS), Basic Trauma Life Support (BTLS), Advanced Trauma Life Support (ATLS), Advanced Cardiac Life Support (ACLS), and Pediatric Advanced Life Support

[57]Army Medical Department Center and School, "Academy of Health Sciences," http://ameddcs.army.mil/ahs.aspx (accessed 19 April 2012).

(PALS).[58] These certifications are managed by agencies such as the American Heart Association and the American College of Surgeons, and provided via the Army Training Network (ATN) to training centers on major installations. These Medical Skills Training Centers (MSTC) also provide Emergency Medical Technician (EMT) training and recertification for enlisted medics. Because they are civilian certifications, and strictly regulated by their offering agency, there is little to no focus on the provision of medical care in a combat environment.[59]

Combat Casualty Care Course

The Army recognizes a need to transition civilian medical training into the military combat environment. Both initial and continuation training for combat prehospital care exist as courses taught at Fort Sam Houston, San Antonio, Texas. During their initial training as a physician, typically in the internship year, Army physicians are required to attend the Combat Casualty Care Course (C4) course. C4 offers a joint field experience in military medicine to Army, Navy, and Air Force medical department officers, and serves as an introduction to the difficulty in providing care in a combat environment.[60] The attendees include physicians, nurses, medical service corps officers, veterinarians, dentists, and many other specialties within the military medical system. Therefore, training in the C4 course focuses on a general delivery of healthcare and does

[58]Defense Medical Readiness Training Institute, "Combat Casualty Care Course," http://www.dmrti.army.mil/courses.html (accessed 18 April 2012).

[59]Army Medical Department Center and School, "Academy of Health Sciences," http://ameddcs.army.mil/ahs.aspx (accessed 19 April 2012).

[60]Defense Medical Readiness Training Institute, "Combat Casualty Care Course."

not provide a detailed level of clinical training. As such, C4 would not be the appropriate venue to introduce systems or protocols discussed in this study.

Tactical Combat Medical Care Course

The Tactical Combat Medical Care (TCMC) course was developed by a group of Physician Assistants at the Army Medical Department Center and School in order to teach current skills in military trauma medicine. An overarching goal of the course is to take the civilian prehospital standards of BTLS and ATLS and modify their techniques for tactical use. During a one week program, TCMC training focuses on the: "1) Initial Assessment of the combat casualty, 2) Initial resuscitation and stabilization, 3) Management of specific combat injuries, 4) Emergency surgical procedures, and 5) Post resuscitation management."[61] The TCMC's target audience includes physicians, physician assistants, and senior enlisted medics assigned to Role 1 and 2 medical units. Because of its prehospital combat focus and the timeliness of the training program, with protocols drawn from lessons learned in Iraq and Afghanistan, TCMC was required training for all physicians deploying to Operation Iraqi Freedom and Operation Enduring Freedom.[62]

TCMC is the only Army medical training for physicians that focuses on the protocols and techniques of combat care in a prehospital setting. Therefore, it is the ideal setting for inclusion of medical protocols reviewed in this study. There are, however, a

[61]Tactical Combat Medical Care Course, "General Information," http://1aeast.army.mil/docs/Coursedescription09.pdf (accessed 19 April 2012).

[62]Deputy Chief of Staff, Army G1, *Personnel Policy Guidance* (Washington, DC: Government Printing Office, April 2012).

few drawbacks to this method. First, TCMC is currently only one week long, and has a full schedule. The addition to the lesson plan of protocols discussed here may necessitate and increased course length. Second, TCMC is limited to 16 students in order to provide an appropriate teacher to student ratio and only has one location.[63] Again, inclusion of additional protocols, and additional students, would require an increase to the program. Finally, the impetus for TCMC participation for the past decade has primarily been as a predeployment exercise. There is no scheduled point in the career life cycle of an Army physician for initial or continuation TCMC training unless they are slated to deploy. These three issues, while requiring more resources for the program and some input from senior leaders in the Medical Corps, are not insurmountable.

Correlates to Other Environments

Techniques and systems outlined in this study have correlates to other areas of medical practice. A number of environments mirror that of an Role 1 or 2 medical unit. Many civilian clinics and hospitals in remote locations on the globe have a single provider such as a senior medical technician, physician assistant, nurse, or physician responsible for delivering care. Third world countries may have only one or two surgical centers, located in major cities, and their standard of care may not meet the level of developed nations. Specialists in mountain medicine operate in small facilities with limited equipment due to the difficulty of delivering supplies to high altitudes and steep slopes. Space medicine practitioners are faced with the ultimate evacuation problem. With few exceptions, medical emergencies in space must be handled without external

[63]Tactical Combat Medical Care Course, "General Information."

support, and an emergency return to earth can take hours to days. These examples point to the benefit of cooperative research between military physicians and specialists in other areas. For example, while the U.S. Army examines the use of ultrasound as a tool on the battlefield, astronauts on the International Space Station are using it to test diagnostic techniques. In both arenas ultrasound will likely serve as a low cost and lightweight adjunct to xray protocols.[64]

[64]Scott A. Dulchavsky, "Using ultrasound in space," National Space Biological Research Institute, http://www.nsbri.org/NEWS-and-EVENTS/Multimedia/Podcast/Using-ultrasound-in-space/ (accessed 19 April 2012).

CHAPTER 5

CONCLUSIONS

Summary

The purpose of this study was to explore the current research involving medical protocols in lieu of evacuation for Role 1 and 2 military medical providers. There are a number of areas where military medical providers could be trained and equipped to provide additional care prior to evacuation to a higher level. The use of ultrasound and the arterial blood collector as diagnostic tools will add capability to Role 1 and 2 facilities at minimal cost. New techniques in fluid and burn resuscitation supplement our current techniques with improved results. Video laryngoscopy allows less proficient providers to sustain an airway with less trauma to the patient. Finally, new techniques to control bleeding such as tourniquets and clotting agents are already showing success on the battlefield. The body of knowledge analyzed in this study shows increased capability for Army first responders and improved survivability for the patients when these protocols are trained, supplied, and used.

Recommendations

Protocols

Inclusion in a literature review does not constitute the basis for change to medical protocols. The addition of any protocol to an organization as large as the Army is a long process. The cost in time and treasure necessitates a greater amount of research that will support these recommendations. Recommendations made in this study are based on a professional analysis of the body of literature, with particular attention paid to the

military applicability of any protocol. This study has shown three areas that warrant immediate inclusion in the Army medical system.

The development of ultrasound as a method of diagnostics is already in progress. Semi portable ultrasonography occurs bedside in most hospitals in the United States. Additionally, this study has shown evidence of organizations such as the United States Institute of Surgical Research (USISR) testing the use of portable ultrasound in the diagnosis and treatment of injury in austere, presurgical environments. Analysis shows that these methods, while moderately expensive, add a tremendous amount of capability to Role 1 and 2 facilities. The lack of xray diagnostics in Role 1 facilities warrants the inclusion of ultrasound as an adjunct therapy. This capability will decrease the necessity of evacuations for diagnostic procedures in fracture cases, and provides a robust group of techniques to diagnose and treat numerous traumatic and nontraumatic maladies. Although the cost may be limiting, fielding of this equipment to medical units that are likely to use it in theater will create a larger network for testing the durability, trainability, and sustainability of the system.

Video laryngoscopy is a valuable tool for prehospital providers in a tactical facility setting. The improved clinical result in the hand of a marginally skilled provider warrants inclusion of this equipment in prehospital sets. Techniques in video laryngoscopy are currently being taught at TCMC, and for many senior medics, it is their introduction to the stabilization of an airway using an endotracheal tube. While the training is valuable, the single afternoon spent on the protocol is too short and un sustainable. Video laryngoscopy should be included in the MSTC centers as an additional skill when Army enlisted medics recertify for BLS or EMT. Additionally, the video

laryngoscope should be included in the MMS for Role 1 and 2 medical sections, but not as a single item in a medics aidbag. The literature does not support laryngoscopy as a protocol for an unsupervised medic in the field, and is more appropriate for a team based trauma setting. With the appropriate supervision, this tool should be available for a physician or physician assistant in the aid station.

The past decade has seen significant advances in blood loss control, with coagulative products being pushed forward for use by combat medics.[65] Army first responder policy has changed to focus on the control of bleeding in the initial moments of traumatic injury. The inclusion of a tourniquet in the Infantry First Aid Kit (IFAK), along with the appropriate training for every soldier, are evidence of this focus. Coagulants provide a powerful adjunct to this line of treatment. While there are significant and irreversible negative side effects with some of the products on the market, the capability to save soldiers who would have previously died warrants additional research. In cases of noncompressible vascular trauma accompanied with arterial bleeding, coagulants may be the only product available to combat loss of life. The Army should commit to the continued development of a bleeding control product for prehospital use, and build coagulative treatments into the training program for enlisted medics.

Future Research

All researchers stand on the shoulders of giants. This study was completed as a foundation for continued improvement to protocols in the area of first responder care.

[65]Bijan Kheirabadi, "Evaluation of Topical Hemostatic Agents for Combat Wound Treatment," *The United States Army Medical Department Journal* (April-June 2011): 25-34.

The literature review showed that there is currently very little consolidated research on medical protocols in the prehospital environment. Most data on the topic is extrapolated from trauma centers in order to improve incomes upon initial presentation to the hospital. Deeper research into this topic should be conducted with the assistance of the Surgeons General of the United States Army, Navy, and Air Force, in order to access prehospital care and evacuation statistics which may not be available to the general public. Additionally, future research on this topic should include cooperation with specialists in the areas of mountain, remote, space, third world, and wilderness medicine. Through cooperation with these governmental and civilian experts, the Army Medical Department will be able to continually discover new innovative and cost effective methods for treating patients in the field.

In order to maintain a focus on prehospital medicine, a national organization dedicated to prehospital care at the doctoral level should be established. The Army, with a large percentage of its physicians at least acquainted with first responder care, should have a leadership role within this organization. Additionally, the true measure of dedication to a field of practice is the development of residency or fellowship training. Providing specialization in a field maintains a group of professionals dedication to the continued improvement of the practice of its tenets. The end result of a medical specialty in Operational Medicine will assist to maintain focus both military and civilian research in the field of operational and prehospital care.

Future Training

Because of successes in helicopter evacuation, Army medical doctrine has shifted towards a focus on medics providing stabilization, MEDEVAC moving the patient

quickly, and surgical centers providing definitive trauma care. The impetus to ensure that Role 1 and 2 medical sections are prepared to provide trauma care is being lost. This trend puts the Army in a perilous situation should we ever return to a linear battlefield with large numbers of combat wounded. In addition to the recommendations above, the AMEDD should include prehospital and first responder care as a part of every physician's career lifecycle. Following the mantra of "every marine a rifleman ," every Army physician should be comfortable with the protocols and equipment in a Role 1 or 2 unit.

The addition of TCMC, or an expanded program, to the beginning of a career and following at regular intervals is a necessity. The single TCMC location could be expanded to three or more. Having additional sites collocated with a major medical center on each coast would to increase accessibility for larger groups of Army physicians. The Army should follow a civilian model of continuation training in these prehospital skills, requiring an initial course during the intern year, and maintenance of a refresher certification. A span of 3-5 years between refreshers, for physicians who are likely to be assigned to Role 1 or 2 medical sections, would keep them abreast on current techniques. Additionally, the current focus on deployment training should continue, with an advanced level course immediately upon assignment to a deployable billet. Finally, physicians serving in first responder medical sections should receive improved training in surgical and trauma resuscitation, to better blur the standard of care between first responder and forward resuscitative care.

Conclusion

No physician wants to remember the patient that could have been saved, but died. This is especially worrisome for Army physicians, who face the possibility of isolation from modern medicine due to their location on the battlefield.

LTC R. T. Gerhardt, an Army physician and trauma specialist, summed up the current trend in military prehospital care in a recent journal article, which was critical of the level of combat casualty care research, "Tremendous successes have been realized in resuscitative surgery, critical care, rehabilitation, preventive medicine, and in our collective ability to project effective medical care into the most austere locations throughout the globe. Innovation in the care rendered outside of theater hospitals or strategic air evacuation conveyances, however, has not kept the same pace."[66] This sentiment reveals the Army's focus on saving lives in the hospital, and evacuating them out of the field as quickly as possible.

The Army's focus may be changing, however. The spring 2011 issue of the Army Medical Department Journal focused on prehospital combat casualty care, with participation in the discussion by senior leaders within the AMEDD. Additionally, over a decade at war has seen major advances in the area of prehospital care. From improved individual aid kits, and increased tourniquet use, to changes in fluid resuscitation protocols, first responder physicians and medic are improving the treatment soldiers wounded in combat. Finally, the lessons captured in Trauma and Combat Casualty Care Courses will continue to sharpen the skills of young physicians choosing a military

[66]Gerhardt, "Prehospital and emergency care research at the US Army Institute of Surgical Research," 82-6.

career. If these advances in training and technology continue to be a have a place in every Army physician's aid bag, the AMEDD will continue to provide world class lifesaving treatment for our soldiers.

BIBLIOGRAPHY

Books

Chairman, Joint Chiefs of Staff. Joint Publication (JP) 4-02, *Health Service Support*. Washington, DC: Government Printing Office, October 2006.

Davis, Jeffrey R., Robert Johnson, Jan Stepanek, and Jennifer A. Fogarty. *Fundamentals of Aerospace Medicine*. Philadelphia: Lippencott, 2008.

Deputy Chief of Staff, Army G1. *Personnel Policy Guidance*. Washington, DC: Government Printing Office, April 2012.

Headquarters, Department of the Army. Army Tactics, Techniques and Procedures (ATTP) 4-02. *Army Health System.* Washington, DC: Government Printing Office, October 2011.

———. Field Manual (FM) 1, *The Army.*Washington, DC: Government Printing Office, June 2005.

———. Field Manual (FM) 4-02.2, *Medical Evacuation.* Washington, DC: Government Printing Office, May 2007.

———. Field Manual (FM) 8-10-1, *The Medical Company: Tactics Techniques and Procedures.* Washington, DC: Government Printing Office, December 1994.

Hogan, David E., and Jonathan L. Burstein. *Disaster Medicine*. Philadelphia: Lippencott, 2007.

Hopperus, Buma, P. C. Adriaan, David G. Burris, and Alan Hawley. *Conflict and Catastrophe Medicine: A Practical Guide*. London: Springer, 2009.

Mahoney, Peter F. *Ballistic Trauma: A Practical Guide*. London: Springer 2011.

McClay, James P., Kim Moore, and David P. Hogan. “Managing Disasters in Extreme Environments.” in *Disaster Medicine*. Philadelphia: Lippencott, 2007.

Schwartz, Richard B., John G. McManus, and Raymond E. Swienton. *Tactical Emergency Medicine*. Philadelphia: Lippencott, 2008.

Whitcomb, Darrel. *Callsign Dustoff- A History of U.S. Army Aeromedical Evacuation from Conception to Hurricane Katrina*. Washington, DC: Borden, 2011.

Research Projects

Edgar, Erin P. “Physician Retention in the Army Medical Department.” Masters of Strategic Studies, Strategy Research Project, U.S. Army War College, 2009.

Hartenstein, Ingo. “Medical Evacuation in Afghanistan: Lessons identified! Lessons Learned?” *Medical Challenges in the Evacuation Chain*. Siegburg: NATO, 2008.

Journals

Chung, Kevin K. “Advances in Prehospital Burn Resuscitation for the Combat Injured.” *The United States Army Medical Department Journal* (April-June 2011): 55-58.

Dubick, Michael A. “Current Concepts in Fluid Resuscitation for Prehospital Care of Combat Casualties.” *The United States Army Medical Department Journal* (April-June 2011): 18-22.

Gerhardt, R. T. “Prehospital and emergency care research at the US Army Institute of Surgical Research: Enabling the next great leap in combat casualty survival.” *US Army Medical Department Journal* (April-June 2011): 82-6.

Holcomb, John B., Lynn Stansbury, Howard R. Champion, Charles Wade, and Ronald F. Bellamy. “Understanding Combat Casualty Care Statistics.” *The Journal of Trauma Injury, Infection, and Critical Care* 60 (2009): 397-401.

Kheirabadi, Bijan. “Evaluation of Topical Hemostatic Agents for Combat Wound Treatment.” *The United States Army Medical Department Journal* (April-June 2011): 25-34.

Lerner, E. B., and R. M. Moscati. “The Golden Hour: Scientific Fact or Medical ‘Urban Legend?’” *Academic Emergency Medicine* (2001): 758–760.

McManus J. G., M. J. Morton, C. S. Crystal, T. J. McArthur, J. S. Helphenstine, D. A. Maasneri, S. E. Young, and M. A. Miller. “Use of ultrasound to assess acute fracture reduction in emergency care settings.” *American Journal of Disaster Medicine* 3, no. 4 (2008): 241-7.

Mitchell, Ray, Joseph Parker, Michael Galarneau, and Paula Konoske. “Statistical Modeling of Combat Mortality Events by Using Subject Matter Expert Opinions and Operation Iraqi Freedom Empirical Results from the Navy–Marine Corps Combat Trauma Registry.” *Journal of Defense Modeling and Simulation: Applications, Methodology, and Technology* 7 (2010): 1-11.

Murray, Michael J. “Review: The Influence of Armed Conflict on the Development of Critical Care Medicine.” *Military Medicine* (2011): 674.

Newgard, Craig D., Robert H. Schmicker, Jerris R. Hedges, John P. Trickett, Daniel P. Davis, Eileen M. Bulger, Tom P. Aufderheide, Joseph P. Minei, J. Steven Hata, and K. Dean Gubler. “Emergency Medical Services Intervals and Survival in Trauma: Assessment of the ‘Golden Hour’ in a North American Prospective Cohort.” *Annals of Emergency Medicine* 55 (2010): 235-246.

Parker, Paul J. “Casualty Evacuation Times: An Evidence Based Review.” *JR Army Med Corps* 153 (2004): 274-277.

Russomano T., S. N. Evetts, J. Castro, M. A. dos Santos, J. Gavillon, D. F. G Azevedo, J. Whittle, E. Coats, and J. Ernsting. “A device for sampling arterialized earlobe blood in austere environments.” *Aviat Space Environ Med* 77 (2006): 453-455.

Venticinque, Steven G., and Kurt W. Grathwohl, MD. “Critical care in the austere environment: Providing exceptional care in unusual places.” *Critical Care* 36 (2008): S284-S292.

Whitfield D. A., and S. J. Portouw. “Retinal Detachment Due to Facial Gunshot Wound: The Utility of Ultrasonography in a Medically Austere Environment.” *J Emerg Med* (2011): 16.

Williamson, K., R. Ramesh, and A. Grabinsky. “Advances in prehospital trauma care.” *International Journal Of Critical Illness & Injury Science* 1 (2011): 44-50.

Websites

American Academy Family Physicians. “Primary Care Physicians and Other Specialists in the U.S., by Percent.” http://www.aafp.org/online/etc/medialib/aafp_org/documents/press/charts-and-graphs/primary-care-physicians-and-other-specialties.Par.0001.File.tmp/no-pricare-phys.pdf (accessed 8 April 2012).

Army Medical Department Center and School. “Academy of Health Sciences.” http://ameddcs.army.mil/ahs.aspx (accessed 19 April 2012).

Association of American Medical Colleges. “Highest Match Rate for U.S. Medical School Seniors in 30 Years.” https://www.aamc.org/newsroom/newsreleases/276900/120316.html (accessed 4 April 2012).

Butler, Frank. “Tactical Combat Casualty Care.” http://www.health.mil/dhb/downloads/Butler%20TCCC.pdf (accessed 5 May 2012).

Cloonan, Clifford. “Profiles in Combat Casualties.” Operational Medicine. http://www.operational medicine.org (accessed 12 April 2012).

Department of Defense Medical Standardization Board. “Department of Defense Directive,” 21 June 1984. http://handle.dtic.mil/100.2/ADA272427 (accessed 4 April 2012).

Defense Medical Readiness Training Institute. “Combat Casualty Care Course.” http://www.dmrti.army.mil/courses.html (accessed 18 April 2012).

Dulchavsky, Scott A. “Using ultrasound in space.” National Space Biological Research Institute. http://www.nsbri.org/NEWS-and-EVENTS/Multimedia/Podcast/Using-ultrasound-in-space/ (accessed 19 April 2012).

General Electric Healthcare. “VScan.” http://vscanultrasound.gehealthcare.com/?utm_source=Google&utm_medium=ppc (accessed 12 April 2012).

Le Cong, Minh. “Brief Review of the King Vision Video Laryngoscope.” EMCrit Blog. http://emcrit.org/review/king-vision-laryngoscope/ (accessed 3 May 2012).

Miles, Donna. “’Golden hour’ initiative pays off in Afghanistan.” United States Air Force. http://www.af.mil/news/story.asp?id=123256862 (accessed 5 April 2012).

O’Leary, Margaret. “A Historical Overview of EMS System Development in the U.S.: the 1960s and 1970s.” Suburban Emergency Management Project. http://www.semp.us/publications/biot_reader.php?BiotID=246 (accessed 4 April 2012).

Rogers, Kara. “Battlefield Medicine: The Golden Hour and the Platinum Ten.” Encyclopedia Britannica. http://www.britannica.com/blogs/2011/06/battlefield-medicine-golden-hour-platinum-ten/ (accessed 8 April 2012).

Tactical Combat Medical Care Course. “General Information.” http://1aeast.army.mil/docs/Coursedescription09.pdf (accessed 19 April 2012).

The Army Surgeon General. “Mission.” The Army Medical Department. http://www.armymedicine.army.mil/about/introduction.html (accessed 4 April 2012).

U.S. National Library of Medicine and National Institutes of Health. “Shock.” Medline. http://www.nlm.nih.gov/medlineplus/ency/article/000039.htm (accessed 11 April 2012).

Newspaper Articles

Little, Robert. “U.S.Military Widening use of Tourniquets.” *Baltimore Sun*, 2 May 2002.

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